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A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

SOLUBLE OILS

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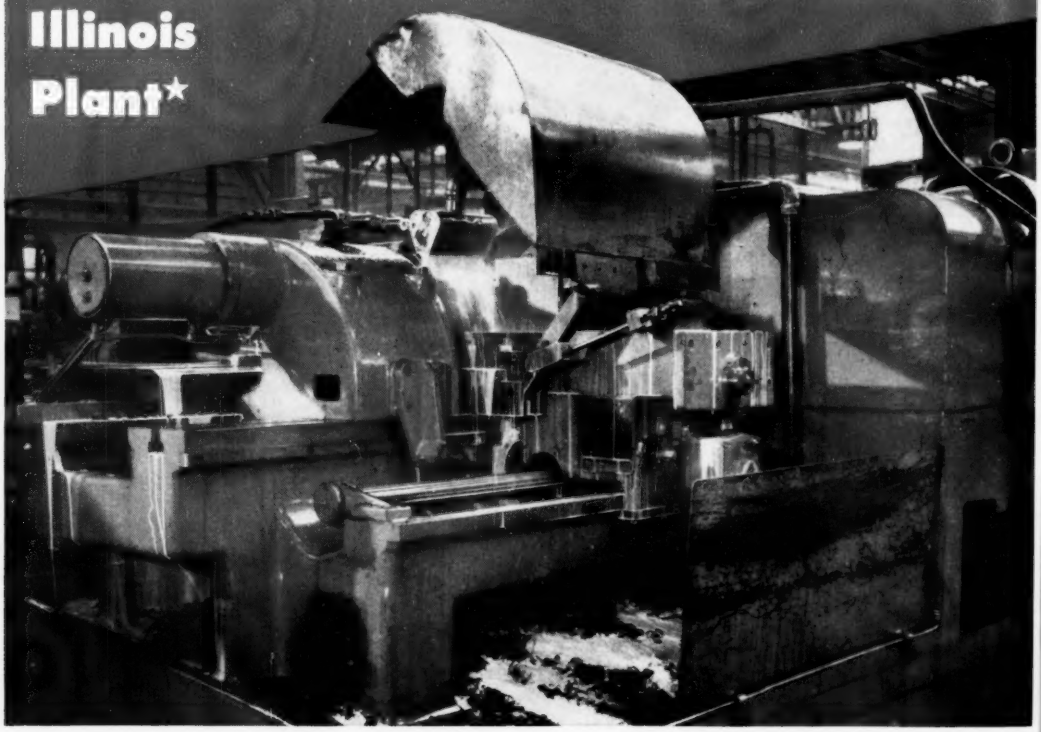

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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SOLUBLE OILS

ANYONE concerned with the machining of metals should be well aware of the importance of cutting fluids to the success of most operations. Frequently a user of these fluids may use such terms as "cure-all", the "great compensator", or the "equalizer" when referring to them. Often he expects them to solve all of his machining problems. Although this is indeed a great tribute, cutting fluids are not miracle fluids. When properly selected, applied and handled, they can be of tremendous benefit. On the other hand, it must be recognized that there are certain problems which cannot be solved simply by the application of a cutting fluid. Nevertheless, the metal cutting industry could not have progressed to its present position were it not for the large variety of such products available today.

Two fundamental physical processes are involved in all metal cutting operations:

(1) formation of the chip from the metal work piece by the tool.

(2) movement of the chip up the face of the tool.

The total work performed by the cutting tool in removing metal is essentially the sum of the work required to form the chip plus that used in overcoming the friction at the tool face. These two quantities are not mutually independent, and usually any factor which affects one of them will affect the other in the same manner. For example, any steps taken to decrease the friction between the chip and the tool also will decrease the amount of work required to form the chip.

Most of the work performed in a cutting operation is translated into heat. This heat can be extremely detrimental both to the cutting tool and to the surface of the machined metal. Exact correlations between temperature, tool life and forces in metal cutting are far from being firmly established. However, there does seem to be a direct relationship between the temperature at the chip-tool interface and the life of the tool. As the temperature increases, the ability of the tool to withstand the forces exerted upon it decreases rapidly. It has been demonstrated rather conclusively that a very small change in temperature can have a very large effect on tool life. Consequently, in the interest of long tool life, the temperature at the chip-tool interface should be kept as low as possible. Also it is frequently imperative, particularly in grinding operations, that the workpiece be kept cool to prevent inaccuracies in dimensions and changes in surface hardness. Thus, any practical means of either removing the heat quickly or reducing the total amount of heat formed, or both, is extremely desirable. Cutting fluids can be effective in both respects. In fact, a cutting fluid can be considered as having two basic functions in the machining process.

(1) To serve as a coolant and remove heat from the cutting tool, workpiece and chips.

Soluble oils used to be rather limited in their applications in the metal cutting industry. Today, however, there are products tailor-made to handle all but the toughest of machining operations.

(2) To serve as a medium for reducing the friction that occurs as the chip slides up the face of the tool.

Mineral oils, either straight or containing additives such as fats, and sulfur and chlorinated materials, are most effective in performing the second of these two functions. The reduction in friction is due partly to simple lubrication but mainly to chemical action. The surface of the chip in contact with the tool face has just been freshly formed from the workpiece, and consequently, it is in a highly reactive state. This condition, together with the high temperatures and pressures existent at the point of contact between the chip and the tool, is very favorable for a chemical reaction. The additives in the cutting oil will react with the chip to form metallic compounds. Thus, instead of an actual metal-to-metal contact, the chip and the tool will be separated by a thin layer of a metal compound. If the shear strength of this material is less than that of the metal itself, there will be a reduction in friction with a resultant decrease in the total amount of work and heat.

For example, both chlorine and sulfur are very effective for reducing the coefficient of friction. The average shear strengths of the stable iron sulfides are about 50% of the shear strength of iron. The average shear strengths of the iron chlorides are about 20% of that of iron. From this it might be inferred that cutting fluids containing chlorine should be more effective than those containing sulfur. This is true under certain conditions. At low cutting speeds, where the temperatures at the chip-tool interface are relatively low, some chlorinated fluids are more effective in reducing friction than are sulfurized fluids. On the other hand, the iron sulfides have much higher melting points than the chlorides. Consequently, as the cutting speeds are increased and the temperatures go up, the sulfurized fluids become increasingly more effective than the chlorinated fluids.

Since the reduction of friction is the result of chemical action, there obviously must be a sufficient amount of time for the reaction to occur. As cutting speeds approach high values and the time of contact becomes less, it is increasingly difficult for a fluid to reduce the friction.

In order for a liquid to be most effective as a coolant, it should have a high specific heat, a high thermal conductivity and a high heat of vaporization. Mineral oils are not among the best fluids in these respects and consequently are not particularly effective in removing heat once it is formed. Actually water is about the most efficient cooling medium known. However, there are numerous reasons why straight water cannot be employed as a cutting fluid. Probably the most obvious one, as well as the most important, is its rust promoting characteristics. Also, it has no value as a lubricant. There is a way in which the additional properties desired can be imparted to water. This is through the use of soluble oils. These are oils wihch have been so compounded that they will form a stable emulsion when mixed with water. Since water is the major component of the emulsions as they are normally used, it still can function efficiently as the coolant. However, the mineral oil and the additives contained therein impart desirable lubricating, anti-friction and anti-corrosion properties to the emulsion. Various combinations of cooling and lubricating properties can be imparted to emulsions by varying the ratio of the soluble oil to water.

WHAT ARE SOLUBLE OILS?

Soluble oils are not really "soluble" inasmuch as they do not form a true solution when mixed with water. As mentioned before, they form an emulsion and actually should be termed "emulsifiable oils". Emulsions are extremely complex systems and it is well beyond the scope of this article to expound the mysteries surrounding them. Countless books have been written on the theory of emulsions and there are still many controversial issues which need to be resolved. However, it is felt desirable to touch on some of the basic concepts in order to present a little better idea of what is involved.

An emulsion is a system containing two separate and distinct liquid phases, one of which is dispersed in the other. The liquid which is broken up into globules is known as the dispersed or internal phase. Conversely, the liquid surrounding the globules is called the continuous or external phase. In the soluble oil emulsions used for machining, the oil is the internal phase and the water the external phase.

When two immiscible liquids are in contact, the boundary between them is referred to as the liquid-liquid-interface. This is not an absolute fine line of demarcation but is actually a zone, due to the interpenetration of both layers. The surface tension at this boundary zone is called the interfacial tension. For two liquids to be completely soluble this interfacial tension is zero. For two non-soluble liquids to form a homogeneous mixture, or an

emulsion, a third substance called an emulsifier is necessary. This will be a material containing two types of molecular groups, one of which will orient in the water phase and the other in the oil phase. Consequently, it will be adsorbed at the interface of the two liquids and make the transition between them less abrupt. In a sense, an emulsifier might be regarded as a bridge connecting two dissimilar liquids. By being adsorbed at the interface, the emulsifier serves to decrease the interfacial tension and permits increased sub-division of one of the liquids in the other. In addition, it provides a film surrounding each particle of the dispersed phase and mechanically prevents them from coalescing with each other. Thus, in picturing a soluble oil emulsion, one might visualize a drop of oil enclosed in a film of emulsifier, which in turn is surrounded by water.

It is probably apparent that the strength and compactness of this interfacial film is the most important single factor favoring stability of an emulsion. This in turn depends largely on the effectiveness of the emulsifying agent or agents employed. To be most efficient, there must be a balance between the strength of the molecular groups that orient themselves in the oil phase and those that orient in the water. The emulsifiers commonly used in soluble oils include soaps of fatty oils, rosin and sulphonates.

Agitation of the three basic ingredients — water, oil and emulsifier — is required to obtain fine division of the dispersed phase. The initial size frequency of the dispersed oil globule offers little clue to the ultimate stability of the emulsion. However, the change in size with time or the rate of change of the interfacial area is a good indication of emulsion life.

TYPES OF SOLUBLE OILS

The first requirement of a soluble oil is that it must emulsify readily with water and form a stable emulsion. Consequently, it naturally follows that the basic or essential ingredient in all such products is the emulsifier. There are innumerable emulsifiers from which to choose but it is impossible to rate their effectiveness categorically. The nature of the oil and also of the water to be used both influence their emulsifying ability. Consequently, a soluble oil manufacturer will choose an emulsifier or combination of emulsifiers which best suits his oil and also, insofar as possible, the type of water with which it will be used.

Some soluble oils may contain nothing other than the emulsifiers. These can be used successfully in limited applications. On the other hand, most soluble oils will contain one or more additives incorporated therein to impart certain desirable characteristics or combat a particular condition that might be encountered in service. Some of these properties are mentioned briefly below.

Rust Protection

Next to having good emulsification properties, the rust protection characteristics of the emulsion are probably the most important. Rusting of machined parts is highly undesirable, since its removal is both expensive and time consuming. All soluble oil emulsions will afford some protection against rust formation, if only by virtue of the oil present. Also some of the emulsifiers used are rather good rust inhibitors in themselves. Products offering only borderline protection against rust can be employed in operations where rich emulsions (high ratio of oil to water) can be used, or where the metals being machined are not particularly prone to rust. However, in many cases the rust protection of these products is quite inadequate. This is particularly true in the machining, especially grinding, of cast iron. For operations of this nature, soluble oils are available which contain rust inhibitors to protect against rust, even at very high dilutions.

High Detergency

Frequently in grinding operations there is a tendency for the wheels to load rapidly and for the machines to become unusually dirty. This is especially noticeable when using a fine grit wheel to remove a small amount of stock. The emulsion wets the portion of the machine with which it comes in contact and as the water evaporates, an oily film is left behind. This film acts very much like flypaper and holds the fine bits of grinding dirt, along with any dust particles that may be in the atmosphere. The result is a very dirty and unsightly looking machine. Such conditions can be improved by using soluble oils containing increased detergency properties. Most of the emulsifiers commonly used in soluble oils are of the surface active type and have good washing characteristics. Thus in some cases, improved detergency is imparted to the oil by using an additional quantity of the emulsifier. In other instances, another material entirely may be incorporated in the oil by the manufacturer.

Soluble oils are extremely complex materials. The ingredients are present in a very delicate balance. Although they are not prima donna products, a certain amount of care should be exercised in their handling and application.

Hard Water

The water used to prepare a soluble oil emulsion will have a pronounced effect on its stability. Actually for best results, distilled water or steam condensate should be employed. Obviously this is far from being practical. In a plant the emulsion must be made with whatever water happens to be available, and it will vary widely in characteristics from place to place. The water may come from a lake or river and be exceptionally soft, or it may be supplied from a deep well and be extremely hard. Hard water is detrimental to the emulsification properties of most soluble oils. The components contributing to the hardness, such as calcium and magnesium, can react with the emulsifier in the oil and form insoluble materials which will separate and form a scum on the surface of the emulsion. That portion of the emulsifier which is so tied up can not perform its intended function, and the resulting emulsion will be deficient in emulsifier. Also the salts in the hard water will tend to be adsorbed in that critical zone at the interface between the oil and the water and cause an increase in the interfacial tension. Thus, in effect, the combination of the depletion of the emulsifier and the adsorption of the salts weakens the bridge holding the oil and water together and makes the emulsion less stable.

Soluble oils are available which have been so compounded as to form stable emulsions with hard water, and they should be used when needed. The question is when are they needed? What constitutes hard water? Although there is no hard and fast rule to follow, it is generally accepted that these hard water soluble oils can be used to advantage when the water hardness is over 300 ppm.

Protection Against Bacteria

Soluble oils are sterile as they are prepared. They are also sterile as they are delivered to the customer. However, bacteria can be introduced in an emulsion either through the water used to prepare it or through contamination of the emulsion in service. If permitted to propagate unabated, bacteria can cause some very undesirable results, as will be discussed in more detail later. They are responsible for the unpleasant "Monday morning odor"; they can promote rusting; and they can cause an emulsion to break. Usually a soluble oil will contain a certain amount of bactericide to afford the emulsion some measure of protection against bacterial growth. Obviously soluble oils will vary widely in this regard, depending on the amount and type of bactericide used.

Extreme Pressure Properties

The main difference between the action of soluble oil emulsions and cutting oils in machining operations has already been discussed. It was pointed out that the emulsions are essentially coolants whereas the cutting oils, by virtue of their extreme pressure and wetting properties, act mainly as lubricants to reduce friction. However, there are increasing numbers of soluble oils available today which contain extreme pressure characteristics. They are generally referred to as heavy duty soluble oils and emulsions prepared therefrom combine good cooling capacity with anti-friction properties. In fact, these products can do all but the most difficult jobs which formerly could be handled only by cutting oils.

From the foregoing, it is apparent that merely identifying a product as a soluble oil gives no information about it except that it will form an emulsion when mixed with water. There are so many different types of soluble oils today, each of which is especially suited for a given application or set of conditions, that additional identification is necessary when describing these products.

MANUFACTURE OF SOLUBLE OILS

Soluble oils are among the most complex products that a lubricants manufacturer is called on to prepare. The ingredients will include the mineral oil, emulsifiers, at least one or more additives, and small quantities of a coupling agent and water. The water is required to increase the solubility of the emulsifiers and some of the additives. The coupling agent serves as a mutual solvent and enables the finished soluble oil to be a clear, homogeneous fluid. It also assists the oil to emulsify.

The final formulation of a soluble oil is arrived at only after a vast amount of laboratory research. Probably no other petroleum product demands such a delicate balance of ingredients. The first requirement of a soluble oil is that it emulsify readily and form a stable emulsion. It matters little how many other special characteristics it may possess; none of them will be of any value if the emulsion is unstable in service and has to be discarded. The amount of the various materials included in a soluble oil to endow it with special properties must be great enough to achieve the desired purpose but not so great as to affect the emulsification properties.

Do not expose soluble oils to extreme temperatures. Low temperatures can cause separation of the ingredients and high temperatures can drive off the volatile components. If possible, store the oils indoors at room temperature.

Preparation of the emulsion is important. Always add oil to the water. Never add water to the oil. The oil should be at room temperature; it should be added slowly; and the mixture should be agitated until emulsification is complete.

Usually there is a very fine dividing line between these opposing factors. This means that the concentration of the ingredients must be very carefully controlled; much more so than with most products. The more ingredients present, the more sensitive and delicate is the balance among them.

This has been a very brief look into the composition of soluble oils, but should serve to give a little indication at least of their complex nature. It is believed that a user of soluble oils who knows even a little about their make-up will be likely to appreciate them more and to exercise additional care in handling them. They are not prima donna products. However, like most products, there are both right and wrong ways to handle them, and frequently it is just as easy to use the right method as the wrong one.

STORAGE OF SOLUBLE OILS

If subjected to sub-freezing weather for an extended period, there is a distinct possibility that stratification or separation of the constituents may occur. Products which have separated usually can be reconstituted by agitation to re-mix the ingredients. However, it is definitely not advisable to expose soluble oils to conditions which invite separation.

Drums should be stored indoors at room temperature if at all possible. If outdoor storage is necessary and there has been danger of separation, drums should be rolled before the product is used. It is also advisable to draw a sample and check the emulsification of the oil before using it. One spoiled drum can cause a lot of trouble.

Frequently soluble oils are delivered in bulk by tank car. During cold weather the product may become so viscous that difficulty is experienced in pumping it from the tank car to the bulk storage facilities in the plant where it is to be used. On such occasions it is not uncommon to employ steam to warm the soluble oil so that transfer of the product may be facilitated. If steam is employed, great care should be taken to assure that no localized overheating of the product can occur. If high pressure steam is employed, it is entirely possible that some of the water and solvent in the product could be driven off. The delicate balance of the ingredients in a soluble oil has already been stressed. Just a minor variation in the concentration can make the product unusable. Consequently, the precautions that should be followed in using steam to warm up a soluble oil can not be overstressed. Actually hot water is much preferred to steam in these instances. However, it is realized that hot water is not nearly as available in the various plants as steam and practical considerations often preclude its use. To repeat, steam can be used but only with extreme caution.

Regardless of whether the soluble oil is stored in drums or in bulk, it is highly essential that it be covered at all times so that contamination may be avoided. The presence of contaminating materials can greatly affect the emulsification and performance characteristics of the product. Cleanliness is perhaps the most important factor in the handling and care of soluble oils from the time they enter a plant.

PREPARATION OF THE EMULSION

One of the most important factors influencing the performance and life of an emulsion is the manner in which it is prepared and the nature of the water used. Concerning the mechanics of preparation, there is very definitely a right way and a wrong way. It is just as easy to employ the proper technique, regardless of whether the emulsion is made in a small bucket or in a large central system.

First of all, the equipment used should be clean. This includes not only the vessel in which the emulsion is to be made, but also any containers used to transfer the oil and water. The temperature of the oil at the time of mixing is more important than that of the water. It should be at room temperature. If the temperature is so low that the product is thick and viscous, difficulty may be experienced in emulsification. Oil should be added to the water. *Never add water to the oil.* This is perhaps one of the most common mistakes made in connection with the preparation of soluble oil emulsions. There is always a danger of forming an inverted emulsion, or a water-in-oil type, when the oil is added to the water. This is most undesirable. There should be at least six or seven times as much water in the mixing vessel prior to the addition of the oil as the total amount of oil to be used. Also for best emulsification, the oil should be added slowly with agitation. This does not mean that it must be added drop by drop, but neither should it all be poured in at once. It is vitally important that agitation be continued until all of the oil is emulsified.

The ease of emulsification will vary from oil to oil. Some will form an emulsion almost spontaneously, while others will require considerable agitation. The nature of the emulsifiers and the type and number of the additives have a pronounced

effect on the ease with which a soluble oil will emulsify. The important point to remember is that an emulsion in which the oil is only partially emulsified will not give optimum performance and usually will cause trouble. Consequently, it is definitely to his own advantage for a user of soluble oils to make sure that the oil is completely emulsified.

Many of the troubles encountered with soluble oil emulsions, such as rusting, odor and separation, can be traced directly to the water used. Consequently, it is likewise to the best interests of the user for him to be thoroughly familiar with the properties of the water which will be employed in the preparation of the emulsion.

As already pointed out, the hardness components of water actually can remove some of the emulsifiers from a soluble oil. If hard water is to be used, there are two courses that can be followed satisfactorily: (1) use a soluble oil that has been prepared especially for hard water application, or (2) soften the water. If the latter is chosen, consult the soluble oil supplier as to what to use and how much. Treatment of the water always should be done before the emulsion is prepared and should be carried out in a separate vessel from that used for preparation of the emulsion. This will prevent the scum formed in the softening process from contaminating the emulsion.

CLEANING SOLUBLE OIL SYSTEMS

In order to obtain top performance and maximum life from an emulsion once it has been prepared properly, it is essential that: (1) the system into which the emulsion is to be installed be absolutely clean, and (2) the emulsion and the equipment be maintained as clean as possible during use.

Although the soluble oils are sterile as delivered, emulsions prepared therefrom can support bacterial growth. If allowed to proceed unchecked, bacterial action can raise havoc with an emulsion. Bacteria can feed on the emulsifier and other ingredients of the oil and eventually break them down and destroy their effectiveness. The products of bacterial action frequently have foul odors which are objected to strenuously by the machine operators. Also these same by-products are acidic in nature and are corrosive.

Never install a new emulsion in a dirty system or machine. Even a small amount of bacteria can inoculate a fresh emulsion. By virtue of their rapid reproductive powers, bacterial growth can soon become so great as to destroy the essential properties of the emulsion.

There are numerous and devious routes whereby bacteria can contaminate emulsions and systems containing emulsions. The water used, the metal parts, workers' hands, refuse cast into an emulsion and even the air are some of the possible sources of bacteria.

The following actual case history[1] illustrates very vividly what happens when fresh emulsions are installed in equipment which has not been thoroughly cleaned. An emulsion used in a new machine did not develop an objectionable odor until six months. With the second batch of emulsion, odor occurred in less than three months, and the time was successively less with the third and fourth batches. Some of the bacteria which entered the system while the first batch of emulsion was in service remained there and contaminated the succeeding batches. It was found that the long emulsion life could be restored by properly cleaning the machine to rid it of bacteria.

In cleaning soluble oil systems and the machines involved, it is mandatory that every bit of surface with which the emulsion may come in contact be thoroughly cleaned. In every system there are sections which are inaccessible to physical cleaning techniques. Yet these areas must be cleaned. It is imperative that no pockets of contamination remain. Consequently, reliance must be placed on suitable cleansing and disinfectant solutions to reach those areas which are not readily accessible. There are numerous such materials available, and the soluble oil supplier usually will be glad to suggest one.

The following is suggested as a general procedure that might be followed in cleaning systems using soluble oil emulsions. This is merely an outline and the actual mechanics can be varied to fit the system involved.

(1) Drain or pump all of the used emulsion from the system

(2) Disassemble as much of the system as possible and manually remove chips, sludge and other contaminants from all accessible surfaces.

(3) Re-assemble equipment and circulate a suitable detergent solution throughout the system. The circulation time will depend on the condition of the system.

(4) Drain the detergent solution and circulate the antiseptic or disinfecting solution. Be sure it reaches all surfaces with which the emulsion comes in contact. If time permits, allow this solution to remain in the

[1]American Machinist, Sept. 18, 1950, Page 116.

system overnight or over a weekend to enable it to penetrate.

(5) Drain the disinfecting solution, flush with water, and re-charge with fresh emulsion.

SERVICE LIFE OF EMULSIONS

Once an emulsion has been properly prepared and installed in a clean system, how long should it be expected to perform before it must be discarded? There is no stock answer to this question. Many factors in service adversely affect the emulsion and tend to shorten its life. The length of time an emulsion will continue to perform satisfactorily will depend largely on how much attention is given to controlling these factors. Obviously this will vary greatly from plant to plant. Some plants take elaborate means to keep the emulsion in service as long as possible. Others take little or no pains with either the preparation, installation or maintenance of the emulsion. Just how far to go in this regard is a matter that each plant must decide for itself. The economic aspects, the nature of the operation and the ease of disposing of spent emulsions are some of the points to be considered.

Some of the factors which work against long emulsion life are discussed briefly below.

Contamination

Leakage of machine tool lubricating oil is one of the most common and likewise undesirable sources of contamination. It is most prevalent in old machine tools which have been in service for a long time and is one of the most difficult sources of contamination to eliminate. It will contribute to the condition of dirty machines and wheel loading, and if allowed to persist, it will necessitate removal of the emulsion. If lubricating oil can contaminate the emulsion, it follows that the emulsion may also contaminate the lubricating oil. This is equally undesirable from the standpoint of machine operation.

Systems containing emulsions are not meant to serve as a refuse disposal, spittoon or wash basin. These are common practices among machine operators and are very effective means of introducing bacteria into the system.

Frequently the parts being machined may in themselves be a source of contamination. They may contain a rustproofing compound or other materials, or they may be just plain dirty or rusty.

Even the air may contribute to contamination of the emulsion. For example, if the machines are near a plating room, the atmosphere may contain acid fumes which would be absorbed by the emulsion. This would contribute to corrosion and emulsion instability.

The service life of an emulsion depends largely on the care and attention accorded to it. Many factors are at work which tend to shorten emulsion life. Elimination of sources of contamination and maintenance of a constant emulsion strength go a long way toward extending the time during which an emulsion will perform satisfactorily.

Loss of Water from Emulsion

As water evaporates from an emulsion, the oil content will become increasingly greater. The end result of this trend, if permitted to continue unchecked, would be an inverted emulsion. It would transform from an oil-in-water system to a water-in-oil emulsion. However, unsatisfactory performance probably would be obtained long before the emulsion inverted. An emulsion of a given strength is used for a particular operation because, after considering all of the factors involved, it is best suited to do the job. The more an emulsion deviates from its original strength, the more unsatisfactory will be its performance.

Loss of Oil from Emulsion

A factor working in the opposite direction is the tendency of chips and grinding dirt to remove oil from the emulsion, thus decreasing the oil to water ratio. Cast iron in particular seems to possess an unusual ability in this regard. As the emulsion leans out, it will decrease in many of its protective characteristics, particularly rust protection.

In this same connection, mention should be made of the bluish-black stain that frequently forms on freshly ground surfaces of ferrous metals. A considerable amount of work is reported[2] on the nature of this stain and the mechanism by which it is formed. The stain itself is believed to consist of ferrous-ferric oxide, or magnetic oxide of iron. The freshly formed chips are highly reactive and can undergo oxidation, which results in ferrous and ferric ions in solution. A tan colored emulsion may indicate a high concentration of ferric ions. It appears that staining can be delayed but not prevented by certain types of inhibitors and by maintaining a constant emulsion strength. Once it has started, however, it usually can not be eliminated. This indicates that once the ferric ion reaches a critical

[2] "Some Problems Encountered In the Use of Soluble Oils" by A. W. Lindert, Lubrication Engineering, Oct., 1951.

concentration, staining will occur. Experience has shown that the use of a hard water soluble oil with soft water will be more likely to give this black stain than if a soft water type product were used. This means that a hard water soluble oil should not be employed unless the condition of the water requires it.

Prolonging Service Life

Thus, three general steps are involved in obtaining the longest possible service life from an emulsion. They apply regardless of whether one machine or a large central system is involved.

(1) Keep close check and control on emulsion strength.

(2) Eliminate as many sources of contamination as possible.

(3) Remove chips, grinding dirt and other contaminants as quickly as possible.

For greatest efficiency, the third step can be subdivided into three stages, (a) separation of metal chips and other solid particles, (b) aeration, and (c) filtration. Separation of solid particles can be accomplished by gravity settling, although the use of magnetic separators may be helpful in some cases. If the emulsion has been used for grinding operations, there will undoubtedly be some grinding dirt which will float on the surface of the emulsion. This can be skimmed from the surface in the settling stage. Aeration of the emulsion will bring to the surface any tramp or non-emulsified oil, which then can be removed. Aeration will also be effective in removing odor due to bacteria. Filtration may not always be necessary, but it is recommended to remove the last traces of any finely divided metal particles still present in the emulsion. There are a variety of filters available on the market which will do the job required without harming the emulsion itself.

A number of techniques can be visualized for performing the various steps involved, ranging from batchwise to continuous operation. The following is an example of a continuous scheme that might be employed in a large plant which uses a central system for distributing soluble oil emulsions.

The emulsions could be transferred from the individual machine tools to the treating area by means of suitable troughs or ditches, care being taken to avoid further contamination during transfer. As a precautionary measure, it is recommended that these ditches or troughs be covered. The emulsion then enters the bottom of a sump or settling basin for gravity separation of the solid particles. The hold-up time should be sufficient to permit complete separation of all the material that will settle out. Metal chips can be removed from the bottom of the sump by means of a mechanical conveyor. Any grinding dirt floating on the surface can be removed by directing a jet of air across the surface and blowing the dirt to one end where it can be picked up by the chip conveyor. The emulsion is then siphoned into a tank where it is aerated to bring to the surface any non-emulsified oil and also to remove odor. The separated oil can be skimmed or over-flowed into a trough for subsequent handling. The clarified emulsion is pumped through a suitable filter to a central tank from which it is redistributed to the individual machines as needed.

Use of Additives in Emulsion

Frequently the user will add various chemicals to a soluble oil emulsion to augment certain characteristics such as rust protection, odor prevention and detergency. It is recognized that in certain cases, such practice can be beneficial in improving performance and extending emulsion life. However the indiscriminate use of such materials can be injurious both to the emulsion and to the operators. If, after selecting the best soluble oil for the conditions involved, it is felt that some property of the emulsion needs to be improved, consult the oil supplier. He will suggest the material and the concentration that may be added safely to an emulsion of his soluble oil.

SUMMARY

Today soluble oils can be applied successfully to all but the toughest of machining operations. They are extremely complex materials, and require a limited amount of care if satisfactory performance is to be obtained.

They should not be exposed to extreme temperatures in storage and precautions should be taken to prevent contamination of the oil. The emulsion should be prepared properly and installed in a clean system. The importance of cleanliness in the handling of soluble oils from the time they enter a plant until the spent emulsion is discarded cannot be over-emphasized.

The length of time an emulsion will perform satisfactorily in service will depend largely on how well controlled are those factors which tend to oppose long emulsion life — such factors as contamination from various sources, changes in emulsion strength and prolonged contact of the emulsion with chips and grinding dirt. Practical and economical considerations usually will dictate how far a user of soluble oil emulsions should go in this regard.

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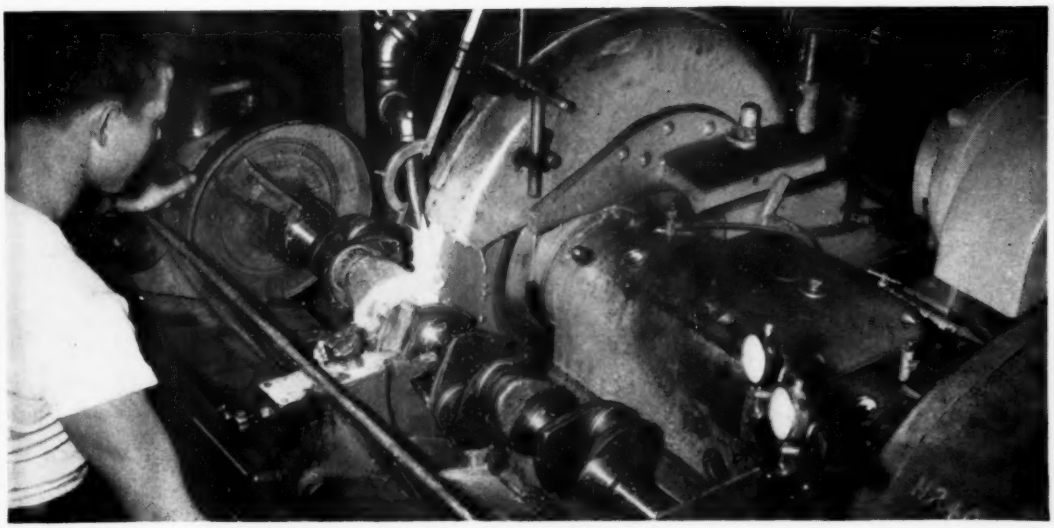
"TEXACO LUBRICATION ENGINEERING SERVICE IS REALLY 'ON THE BALL'"

—Norman Nesbitt, Purchasing Agent, Atlas Crankshaft, Inc., Fostoria, Ohio



ATLAS CRANKSHAFT, INC., has been using *Texaco Soluble Oil* in its grinders for a good many years—getting fine results in finish, rust prevention, emulsion stability and cleanliness. But Atlas is particularly pleased with the service that goes with Texaco products. Mr. Norman Nesbitt, Purchasing Agent, writes:

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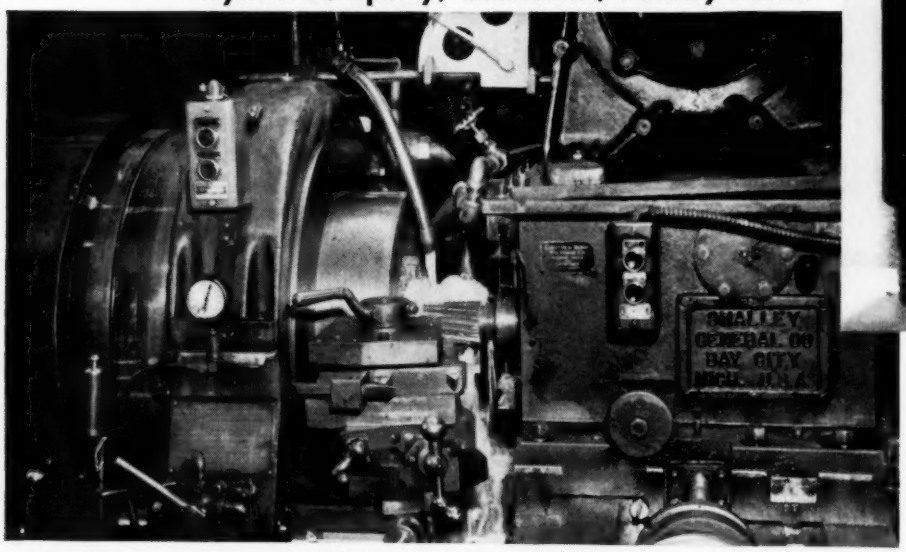

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